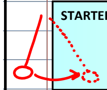
(d)	solutions to the equation $a = -\omega^2 x$ e.g. $x = A\cos\omega t$ or $x = A\sin\omega t$	M3.9, M3.12
(e)	velocity $v = \pm\omega\sqrt{A^2 - x^2}$ hence $v_{max} = \omega A$	M2.2
(f)	the period of a simple harmonic oscillator is independent of its amplitude (isochronous oscillator)	
(g)	graphical methods to relate the changes in displacement, velocity and acceleration during simple harmonic motion.	HSW1

(6) M - Apply the equations of SHM to find the displacement of an oscillator
(7) S - Calculate the velocity of an oscillator
(8) C - Use a graphical methods to relate changes in displacement, velocity and acceleration during SHM

Lesson 2. Graphing SHM

0:00:00



STARTER: A short pendulum oscillates with s.h.m. such that its acceleration a (in m s^{-2}) is related to its displacement x (in m) by the equation $a = -300x$. Determine the frequency of the oscillations.

Answer

Kilo 10^3
Mega 10^6
Giga 10^9

$2.76\,Hz \approx 2.8\,Hz$

Key point

HWK (due next lesson): Complete Summary questions: P

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(6) M - Apply the equations of SHM to find the displacement of an oscillator
(7) S - Calculate the max velocity of an oscillator
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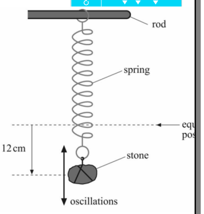
Example SHM question

0:00:00

The stone is displaced 12cm from the equilibrium position and then released. In a time of 45 seconds the stone executes 30 oscillations.

~~Calculate the maximum acceleration~~ of the stone.



Kilo 10^3
Mega 10^6 Ex: Determine the
Giga 10^9 ~~displacement at time = 2s~~

The period T is given by:

$T = \frac{45}{30} = 1.5\,s$

The acceleration of the stone is given by:

$a = -(2\pi f)^2 x$ or $a = -\left(\frac{2\pi}{T}\right)^2 x$

The acceleration is a maximum when the displacement x is equal to the amplitude A of the motion, which is 12 cm. Therefore the magnitude of the maximum acceleration is:

$a = \left(\frac{2\pi}{1.5}\right)^2 \times 12 \times 10^{-2} = 2.11\,m\,s^{-2} \approx 2.1\,m\,s^{-2}$

The displacement x of the stone after 2.0 s is given by:

$x = A\cos(2\pi ft)$

$x = 12 \times 10^{-2} \times \cos\left(2\pi \times \frac{1}{1.5} \times 2.0\right) = -0.06\,m$

The stone is released from its maximum displacement at $t = 0$. Hence the displacement x must be given by the cosine relationship.

After 2.0 s the stone is displaced a distance of 6.0 cm *above* the equilibrium position.

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(6) M - Apply the equations of SHM to find the displacement of an oscillator
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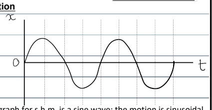
Other equations of SHM

0:00:00

Key point

Displacement equation

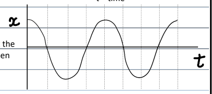


The displacement-time graph for s.h.m. is a sine wave; the motion is sinusoidal.

x = A sin (2πft) $x = A\sin(\omega t)$

A = amplitude
ω = angular frequency
t = time

If displacement starts at the maximum amplitude, then



x = A cos (2πft) $x = A\cos(\omega t)$

You must be careful when choosing which equation to use: always check where the object's starting point is.

Calculator must be in RADIAN mode.

Velocity equation

$v = \pm\omega\sqrt{A^2 - x^2}$

x =
v =
f =
A =

Max velocity equation

$V_{max} = \omega A$

$v_{max} = 2\pi fA$

v_{max} =
f =
A =

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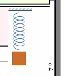
0:00:00

ACTIVITY:
Oscillate a 0.5 Kg mass on a spring starting from max displacement of 10cm Record the **amplitude** and find the **time period <u>accurately.</u>** Calculate the **frequency. Complete the table.**

Sketch the graphs of x against t a against time and v against time

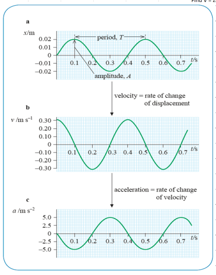
Kilo 10^3
Mega 10^6 How did you ensure your time period was accurate
Giga 10^9 Extension on worksheet



Key point

t (s)	t (T)	f	ω	x	a	v
	0					
	T/8					
	T/4					
	3T/8					
	T/2					
	5T/8					
	3T/4					
	7T/8					
	T					

Find V=max
Find V = Zero



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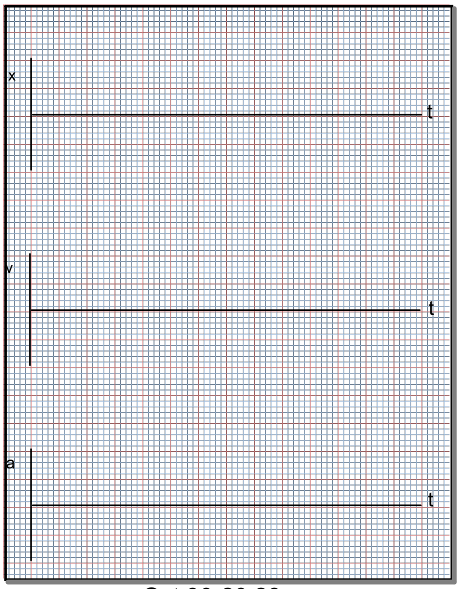

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(6) M - Apply the equations of SHM to find the displacement of an oscillator
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Plenary

0:00:00

14 The vibration of a component in a machine is represented by the equation:

$x = 3.0 \times 10^{-4}\sin(240\pi t)$

where the displacement x is in metres. Determine the **a** amplitude, **b** frequency and **c** period of the vibration.

Answer

a 3.0×10^{-4} m (0.30 mm)
b 120 Hz
c 8.3×10^{-3} s

Key point

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